APPENDIX C.
UNDERGROUND (SUBSURFACE) MINING METHODS

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SURFACE-RELATED: AUGER MINING AND HIGHWALL MINING

For coal seams that are too deep for surface mining and also too small to warrant extensive underground mining, auger mining and highwall mining methods can be used. The coal seams must be exposed or easily accessible by the highwall of a surface mine or other excavation.

AUGER MINING

Generally, auger mining is used for recovering coal beyond that which is accessible by contour strip-mining (Figure A1). This method is limited to coal seams that are horizontal or slightly pitched. Auger mining can create pits up to 500 feet into the highwall (Crowell 2001) depending on the conditions of the site and the type of auger used. This mining method is generally inexpensive; however, coal recovery rates are low.

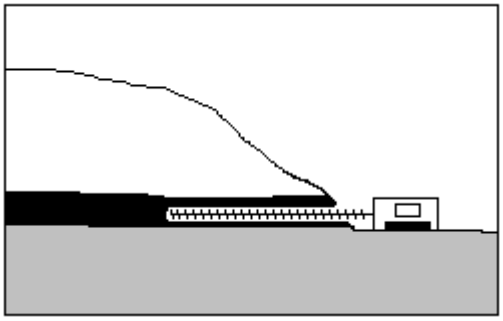

Figure A1. Auger mining into a coal seam.

HIGHWALL MINING

Highwall mining is another method used when an otherwise inaccessible coal seam is exposed by contour strip mining. In this method, a continuous mining machine operated remotely is driven into the exposed seam. The haulage system on the machine brings the coal out of the tunnel to be collected and stockpiled. In this method, drives into the seam are separated by long, parallel coal pillars that support the overburden (Figure A2). The width of these support pillars must be based on the geologic conditions of the site. The maximum recovery rate of this method is higher than that of auger mining although continuous mining machines require more capital investment.

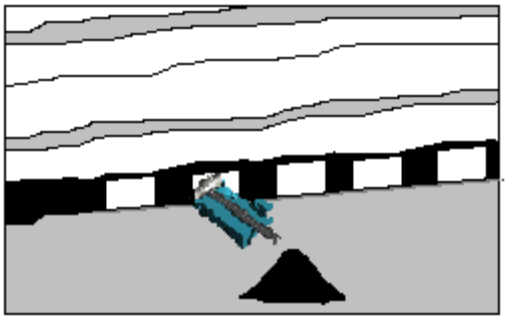

Figure A2. Highwall mining into a coal seam.

UNDERGROUND: ROOM-AND-PILLAR MINING AND LONGWALL MINING

Underground methods are used when the coal reserve is 300 feet or more below the surface of the earth. These methods, room-and-pillar mining and longwall mining, require heavy machinery and a greater degree of capital investment than the surface-related methods. Machinery used in underground mining includes continuous miners, shuttle cars, drills, cutting machines, and tractors. Underground mining also requires ventilation and airway systems, dust control, fire prevention, electrical power and communication systems (Given et al. 1973).

ROOM-AND-PILLAR MINING

In this form of underground mining, coal is removed from a seam in such a way that rectangular or square pillars remain in order to support the overburden (Figure A3). In most cases, coal seams must be relatively flat (maximum 5 to 6 degrees pitch), although steep pitch mining methods also exist. Seams must be large enough to allow heavy machinery such as shuttle cars and tractors through easily (Given et al. 1973).

With this method there is flexibility as to which areas of the seam are to be mined; areas with high quality materials can be extracted while areas of lower quality material can be left as overburden support. Discontinuing extraction in areas that are not economically convenient is relatively simple. It is also easy to adapt the shape of the mined area to fit the outline of the seam. Depending on the site conditions and the goals of the mining operation, the pillars can either be left in place or removed when mining is complete (Given et al. 1973).

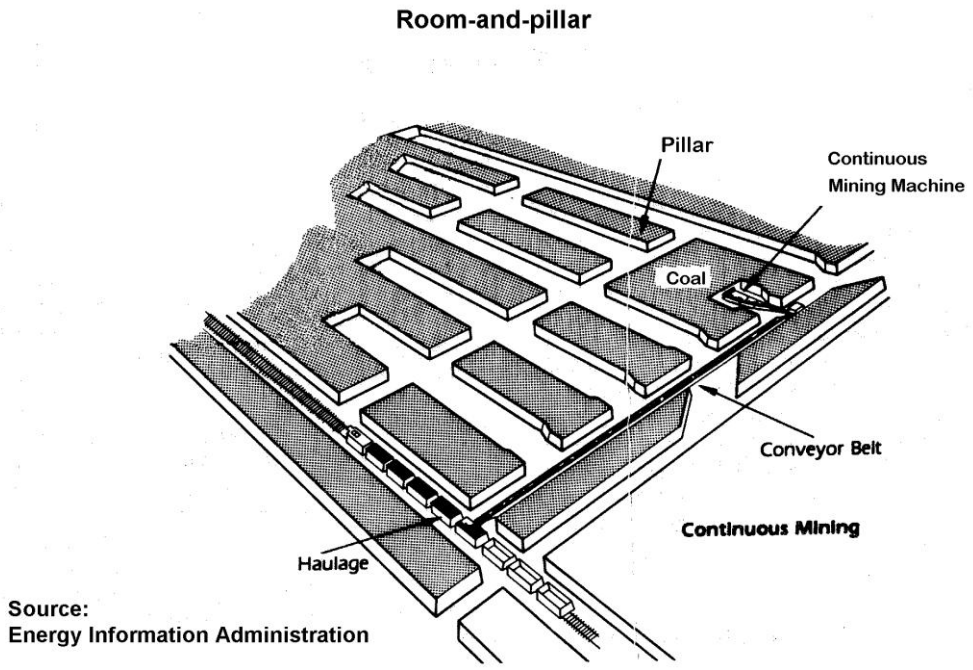

Figure A3. Room-and-Pillar mining method.

LONGWALL MINING

In areas where coal veins are relatively flat and expansive, longwall mining can be used in conjunction with room-and-pillar mining. In this method, large continuous blocks of coal are isolated within a seam (Figure A4), either by room-and-pillar areas or with the use of roadways. These blocks are usually 200 to 600 feet wide and up to several miles long. Conveyor systems are set up along the sides and faces of the blocks to carry coal to areas where it can be loaded and stockpiled (Given et al. 1973).

A machine called a shearer is drawn along the face of the block of coal that is opposite the mine entry (Figure A5). The roof behind the shearer is supported by hydraulic jacks that are around 5 ½ feet wide and up to about 20 feet tall placed in a long line. When the shearer has reached the end of the longwall face, these roof supports automatically move forward about 3 feet so the shearer can begin a new pass. Once the roof supports have advanced, the overburden behind them is allowed to collapse (called the "gob" or "goaf" area). The coal cut by the shearer falls onto a conveyor system that brings it to where it can be loaded into trucks and stockpiled (Given et al. 1973).

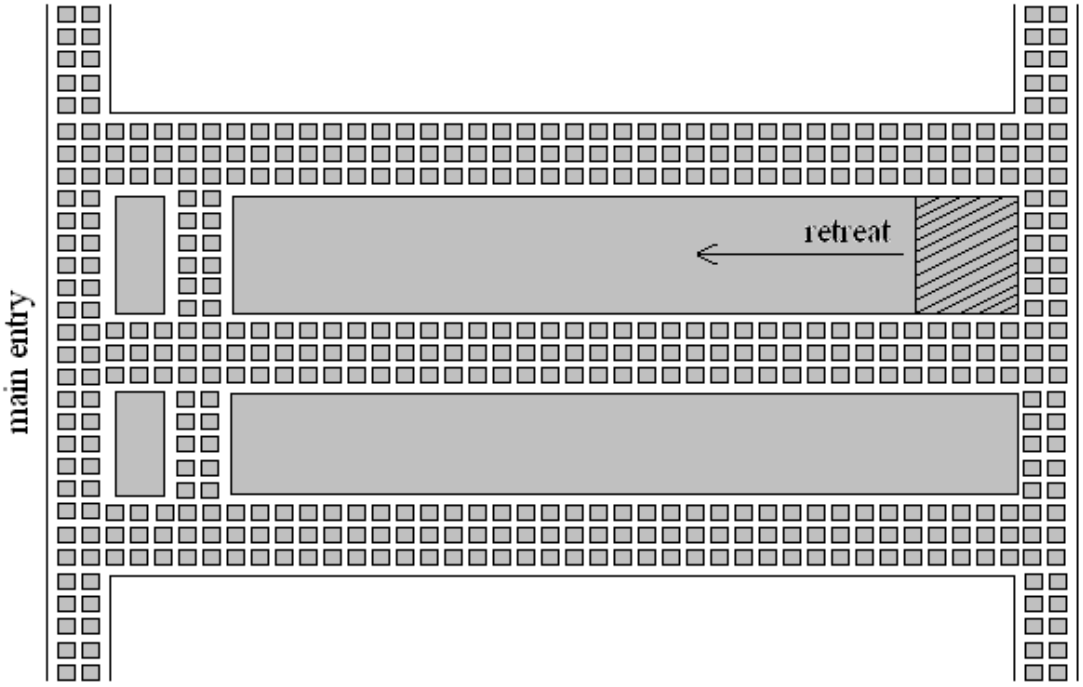

Figure A4. Longwall mining areas outlined with room-and-pillar areas. Longwall machinery is set up on the face of the block of coal opposite to the main entry to the mine. Coal is mined towards the mine entry. (Adapted from Given et. al 1973).

The benefits of longwall mining include a greater coal recovery rate than the room-and-pillar method and enhanced safety for mine workers due to the hydraulic roof supports. A detailed diagram of longwall mining is shown in Figure A5. A photo taken in a longwall mine is shown in Figure A6.

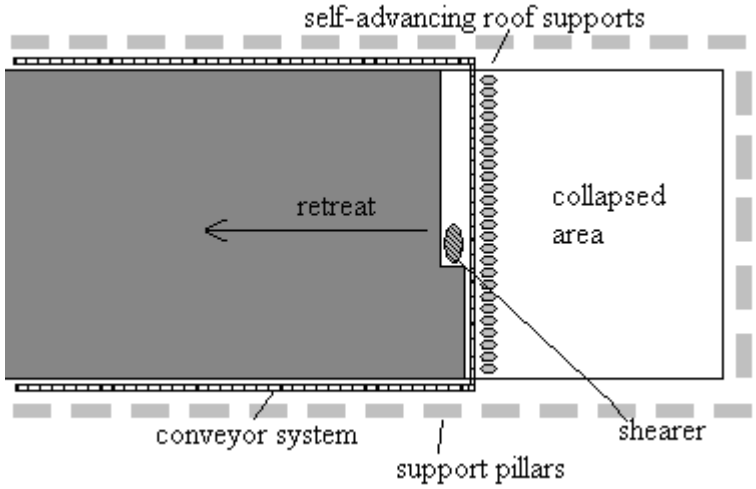

Figure A5. Detail of longwall mining.

Figure A6. Photo of longwall mining machinery including the shearer and the self-advancing roof supports (Hill-Douglas 2007).

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